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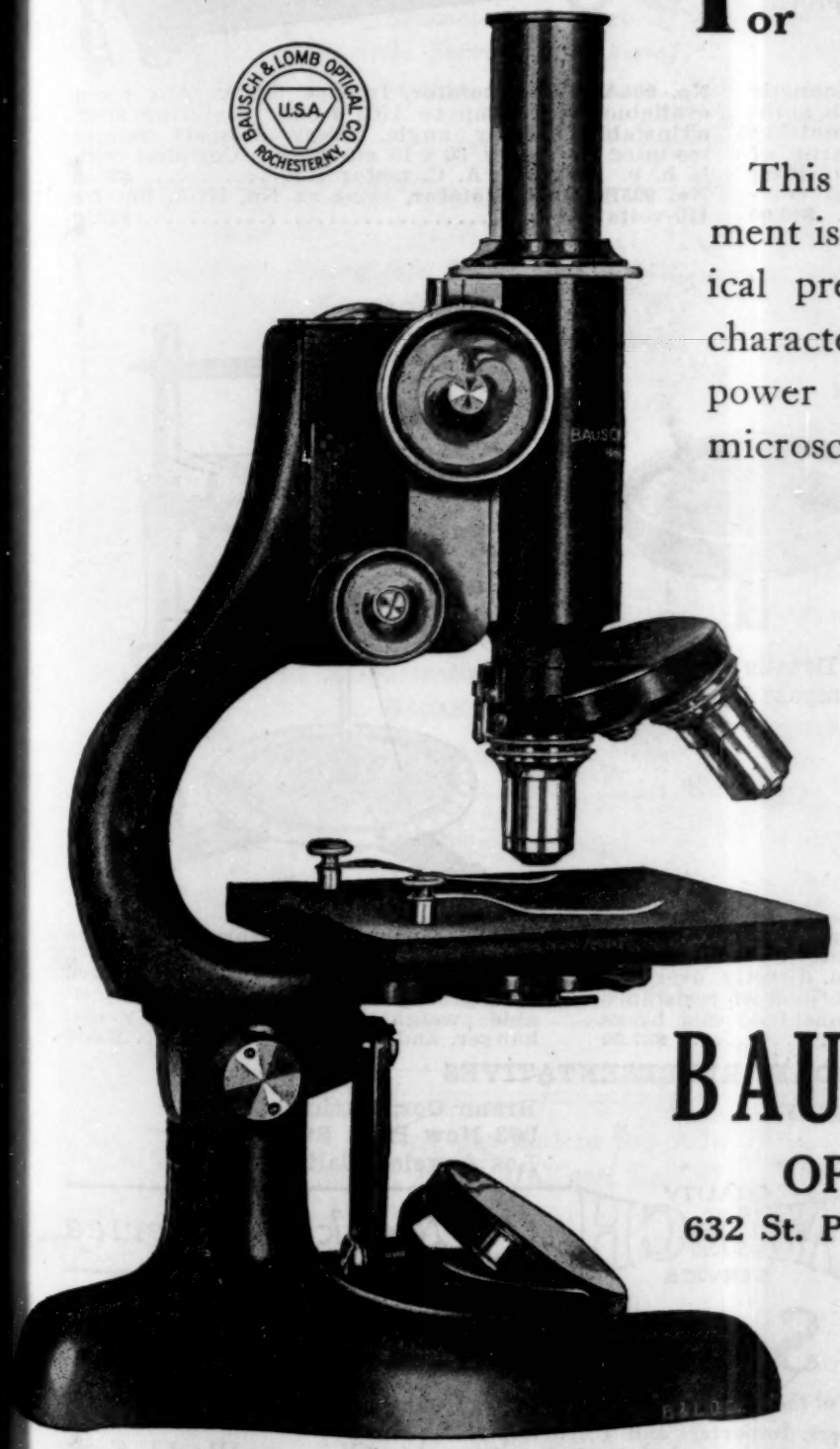

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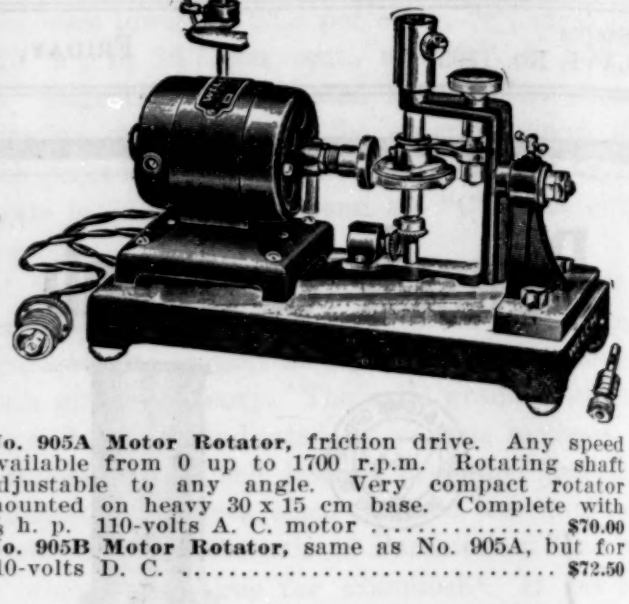

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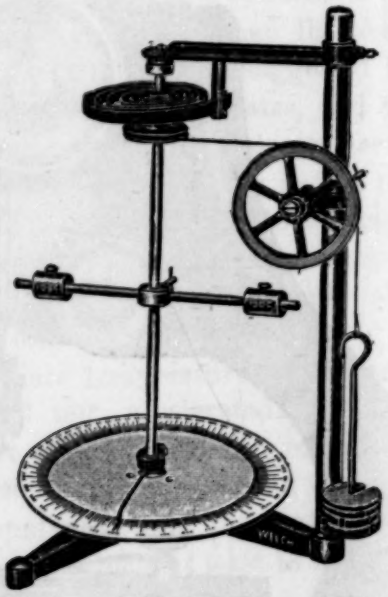

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SCIENCE

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JOSIAH WILLARD GIBBS AND THE EXTENSION OF THE PRINCIPLES OF THERMODYNAMICS

FIFTY years ago there was being published in the *Transactions* of the Connecticut Academy of Sciences a paper by Josiah Willard Gibbs, then professor of mathematical physics at Yale. This paper bore the title, "On the Equilibrium of Heterogeneous Substances." To-day from various parts of the world come notices and reports of meeting of societies and groups of scientific men engaged in apparently most diverse lines of investigation or industry, who, recognizing the lapse of fifty years and the changes they have brought, pause to recall the event of the publication of Gibbs's paper and to pay superlative tribute to the intellect and accomplishment of a man who influenced so profoundly the remarkable scientific progress made during this period.

It is therefore appropriate to call attention at this time to some of these memorial tributes and in particular to some of those expressed at the recent jubilee celebration held in his honor by the Chemical Society of Holland; for by quotations from them it may be realized through the words of eminent scientists the high esteem in which the most eminent American man of science is held throughout the world. By this means, too, something may be conveyed of his character, his industry, his wonderful ability for taking pains, and chiefest, his commendable lack of self interest in research.

It is worth while also to refer to the environment of Gibbs, since the environment of a man—especially the intellectual environment of an intellectual man—is an essential part of him and may largely determine the form and direction his intellectual activities shall take.

The period covered by the life of Gibbs, 1839–1903, was marked by an unusual interest and activity in physics. It is only necessary to recall the names of eminent physicists of that period to be assured of this. This interest, too, was general, and in so far as it pertained to the people at large, was inspired by the relation, then becoming more and more obvious, between the useful and practical applications of physics to industry and commerce. Industry was beginning to establish its laboratories and seek the leadership of scientific method.

The concept of energy was emerging during the early life of Gibbs and although not yet seen with

enough precision to require a name and definition attempts had nevertheless already been made to define the possibilities of machines. In 1847 appeared the paper of von Helmholtz, "Die Erhaltung der Kraft," which needed only the substitution of the word *Energie* for that of *Kraft* to reveal in a most extended sense the principle of the conservation of energy that found so rational a place beside the principle of the conservation of mass that had earlier found expression.

The situation in physics during the formative years of Gibbs was not greatly unlike that that surrounds a young student at the present day. The attention is intensely directed to a new vision just ahead and its alluring possibilities. In the early years of Gibbs it was the concept of energy and the dynamical theory of heat, out of which ultimately grew the formulation of the first and second laws of thermodynamics and, in these still later days, the Theorem of Nernst. In the present day the vision is also alluring for it always pushes forward. It now seeks, though not an ultimate, yet a still more inclusive generalization through a better knowledge of the structure and mechanism of the atom. There is now scarcely any phase of physics uninfluenced by this new development—just as in Gibbs's youth the major interest was in statistical mechanics and thermodynamics.

Gibbs followed the trend of his time. He sought the inspiration and instruction of the pioneers who were establishing the laws and principles of the then new development in physics. The years 1867 to 1870 he spent as a student in Europe, studying there physics and mathematics, and, among other sources receiving inspiration from Magnus, Helmholtz, Kirchhoff and Clausius. These names are inseparably connected with the development of the principles of thermodynamics.

After his return from Europe, Gibbs was elected to the professorship of mathematical physics at Yale, 1871. The direction of his activities had now been determined even to subject and method. All his subsequent effort was to be directed to the mathematical analysis and investigation of thermodynamic problems. His methods were naturally influenced largely by those of Clausius and the problems he at first interested himself in referred to homogeneous systems. He employed the Carnot-Clausius cycle and the Clausius concept of entropy. In the prosecution of these earlier studies Gibbs made rapid progress. He greatly extended the graphic method of analysis. He invented the system energy, entropy, volume which proved of great value. This attracted the attention of Maxwell, whose last effort before his early death was to mould with his own hands a model developed from these three dimensions. This he sent to Gibbs. Gibbs is probably as well known through the graphic methods he introduced as by his more important theoretical contributions.

The problems possible of solution by the methods of Clausius and by those of Gibbs up till 1876 were confined almost exclusively to homogeneous systems. Besides, there entered into these analytical methods what further limited their practical applicability, *viz.*, the concept of reversibility. In reality most of the processes of nature and those most useful to men are irreversible and involve heterogeneous not homogeneous systems. To extend the principles of thermodynamics to include non-reversible and heterogeneous systems would be to make them universally applicable. This was an exalted vision; yet such a vision was the natural outcome of the progress that had already been made. Clausius had expressed this universality in the well-known couplet formulating the first and second law:

Die Energie der Welt ist konstant,
Die Entropie der Welt strebt einem Maximum zu.

This couplet—significant of the influence of Clausius, and recognizing no mechanism nor theory—Gibbs used as a text or sub-heading to his memorable paper "On the Equilibrium of Heterogeneous Substances."

The writings of Gibbs, however, show plainly that he early recognized the possibilities that might result from an extension of atomic and molecular theories and the use of statistical methods. But he realized also, at the time he was working, the meagerness of definite knowledge then existing for a more extended atomic theory. It will be noticed also from a quotation to be made that Ostwald was of opinion that the value of Gibbs's paper rests on the fact that he concerned himself exclusively with energy magnitudes and wisely avoided all kinetic hypotheses.

In the application to life and industry of fundamental principles of science that had already been formulated, the last fifty years have been the most active and productive in the world's history, even though they may not have been the most productive in the discovery of new ones. The result of the severe scrutiny and test of those years upon the work of Gibbs is perhaps nowhere better revealed than in the tributes publicly paid to his memory and accomplishments by those qualified to make use of and judge them.

That so important a piece of work should remain for fifteen years practically unknown after its publication in America is worthy of much contrite reflection—for the work itself is a model of what American thoroughness joined to vision can be, while its techni-

cal and public neglect over so long a period offers an equally notable example of what American haste and superficiality continue increasingly to be.

But some rumor of Gibbs's work finally did reach Europe; Öttingen mentioned it to Ostwald; Ostwald investigated—being particularly interested in the subject of chemical equilibrium. In his autobiography, "Lebenslinien," now being published, he recounts the incident quoted at the Holland celebration:

> Öttingen had already mentioned to me while I was yet at Dorpat the existence of a work on thermodynamics by an American physicist. He had referred to it as significant, but difficult to follow.
>
> In order to make myself clear concerning this mightiest of all means (thermodynamics) for developing a theory of chemical affinity, I began the study of Gibbs's paper after no little difficulty in trying to secure a copy of it. My experience with the paper tallied with that of Öttingen—I found it difficult to make headway in it, yet I recognized, and that without a doubt, its immense importance. Not many had anticipated me in the recognition of this work; previously, only Maxwell in England and van der Waals in Holland had referred to it.
>
> There seemed no other way possible for me to gain an understanding of the work than to translate the paper word for word. An abstract of it was impossible because it was already so condensed that further abbreviation was out of the question. It was also my thought that by a German translation and publication of this long-neglected masterpiece it could be brought to light and allowed to take the place that its importance should merit among other investigations.
>
> Gibbs's paper proved of the greatest influence on my own development, for—although he did not emphasize the point nor even mention it—Gibbs concerned himself exclusively with energy magnitudes and their factors and avoided completely all kinetic hypotheses. By so doing he won for his results a permanence and security that has placed them among the highest products of intellectual attainment. It is a fact that up to the present time, not a single error either in his formulae, his results, nor yet—and this is the most remarkable—in his assumptions has been found. Among scientific articles there are to be found not a few wherein the logic and mathematics are faultless, but which for all that are worthless because the assumptions and hypotheses upon which the faultless logic and mathematics rest do not correspond to actuality. In this most important respect the work of Gibbs is free from error.
>
> This important work of the gifted American physicist was published by me (with his cooperation) in 1892 (fifteen years after its publication in America) under the title, "*Thermodynamische Studien.*" This was for a long time the only form in which this most significant contribution was available to the scientific world. . . . The German edition was soon exhausted and the book has long been out of print. It thus oddly came about that English and American students were obliged to study a work in German originally published but not available in the English language. Not until 1906 (thirty years after its first printing and three years after its author's death) Longmans brought out *in England* an edition of the few papers ever published by Gibbs. A German edition is now no longer necessary.
>
> Willard Gibbs was an excessively modest and reserved genius. His entire life, with the exception of a few years spent elsewhere in study, was passed in New Haven, Connecticut, where his father before him was a professor in the university. Of his greatness—he is without question the greatest scientific genius the United States has produced—neither the citizens of his native town nor yet of America had any conception. He was to be discovered first in Europe. This occurred in Holland through the physicist van der Waals—in Germany through Öttingen and myself. In Holland an entire school of followers beginning with the student of Bemmelin, Bakhuis Roozeboom, has developed around a single one of the many generalizations that Willard Gibbs arrived at and published in his great work. The nucleus of the Holland group is the Phase Law of Gibbs. It was thus that by degrees the scientific world became aware that in Willard Gibbs dwelt a mind worthy to rank along side those of the great physicists Helmholtz, Clausius and W. Thompson.
>
> The close consideration that I was compelled to give to the work of Gibbs in order to translate it was of great advantage to me. Although I was able to follow his mathematical processes only incompletely, I nevertheless acquired from the attempt to follow them an invaluable method of thought. I learned the value of the straightforward reality with which he grasped the separate problems and the exhaustive vision with which he marshaled his equations and developed from them far-lying consequences. Also I could not help but realize that the two hundred equations that his work embraced were, without exception, equations dealing with purely energy magnitudes. For me this fact had the greatest significance for it showed that *every fundamental Arbeit must be a work based upon the fundamental laws of energy.*"

Besides Ostwald, to whom the memory of Gibbs must owe a special debt of gratitude, many other Europeans participated in the jubilee celebration of the publication of Gibbs's work held by the Holland group.

Le Chatelier paid his respects to the memory of Gibbs upon this occasion. In his contribution he attributed to Gibbs the rôle of creator and designates his creation as the immense domain of *Méchanique Chimique*. He said:

> This chapter of science Gibbs created and added to human knowledge where nothing had existed before; and this creation of his was so complete and perfect as it came from his hands that the fifty years that have passed have been able to add little or nothing to it. The numerous savants who have in the meantime concerned themselves with like questions have accomplished

little more than a paraphrase of his work. They have perhaps completed some points in more detail; but more often they have only applied to particular cases laws formulated by Gibbs. Gibbs deduced and expressed his Phase Law in two pages; but there have been published many large volumes recording divers applications of it.

In 1899, twenty-two years after its American printing and five years after Ostwald's German translation appeared, Le Chatelier translated into the French language and published the paper of Gibbs.

An important tribute to the accomplishment of Gibbs was expressed by Professor Donnan, of London, whose notable work on membrane equilibria is one of the manifold applications of the principles formulated by Gibbs and here applied to thermodynamic investigations of life processes. It was Donnan's tribute to Gibbs on the occasion of the centenary celebration of the founding of Franklin Institute that came to many of our countrymen as a matter of news—came as a front page announcement of a great discovery—twenty years after the death of Gibbs. On that occasion he referred to the paper of Gibbs as "one of the mightiest works of genius the human mind has ever produced." In his contribution to the Holland jubilee, instead of dealing with his own special work and the relation it bore to the generalization of Gibbs, he dealt with the great unifying influence of the work of Gibbs as shown in the diversity of its application and in particular he dwelt on its immense practical value to industry. He said:

> The systems with which the chemist is called upon to deal in the carrying out of industrial processes are usually of extreme complexity when viewed from the standpoint of kinetic and electronic theory. The exacting demands of modern life do not allow him to confine his labors to ideal solutions or ideal gas mixtures or to monatomic crystals in the neighborhood of absolute zero. The rapid advances of physics and physical chemistry in modern times undoubtedly hold out the hope that the time will come perhaps in no very distant future when the structure and activity of the material world will be understood in terms of a theory based on the potentialities and activities of electrons, protons and radiation, or possibly of radiant energy alone. Although such a theory already exists in outline, it is not sufficiently developed to suffice for the immediate needs of the chemist who is called upon to devise and control technical processes involving concentrated solutions of complex composition and often containing substances of complex molecular structure. During the past thirty or forty years, however, chemical science has been able to utilize, with immense benefit to itself, that part of physical science known as thermodynamics whereby the most complex equilibria can be dealt with quantitatively without any knowledge of the intimate "mechanisms" underlying physical and chemical phenomena. We owe the first complete and general exposition of the thermodynamics of multiple component systems, especially in relation to heterogeneous equilibria to the pioneer work of Josiah Willard Gibbs in the late seventies of the last century. . . . Donnan concludes his tribute by quoting from Sir William Pope the words referring to Gibbs's Phase Law, "Who would have believed thirty years ago that the Phase Rule of Willard Gibbs would to-day be an important accessory to the manufacture of a number of heavy chemicals? Yet the men who learned the principles of this seemingly mathematical abstraction as students have revolutionized a great branch of chemical industry.

The address upon this occasion by Tammann, whose *Fach* is metallurgy and whose interests might seem remote from the physics of life processes that chiefly interest Donnan, contains this sentence:

> Never has an abstract investigation so influenced the fundamental basis of industry as has the treatise of Gibbs on heterogeneous equilibrium.

Such quotations could be indefinitely extended. Those that have been given are not ephemeral; they are based by their authors upon a long and profitable personal experience leading to an ever-increasing knowledge and appreciation of the beauty, utility and value of the work of Gibbs. It has been mentioned that the universality of the principles of heterogeneous equilibrium was fully realized by Gibbs. The extent to which they have been realized in actuality is witnessed by the great number of investigations they have inspired and by their important results. These investigations cover the most diversified fields of human interest. A coordination of them in simple understandable terms would form one of the most interesting chapters in *Naturphilosophie*.

The hearty and sincere tributes of Europe to the American scholar might suggest one basis at least on which international amity is secure. But international amity even on so ideal a basis is not secure the moment the practical application of pure science is made by industry, and by the industry of that nation the best qualified to make application of it. Not only was the value of the work of Gibbs in the field of pure science first recognized by Europeans—the source from which the inspiration of Gibbs was wholly drawn—it was in Europe also that it found its most extensive and efficient application. The laws of heterogeneous equilibrium are the laws upon which are based industrial synthetic processes. Commerce has become familiar with many of its products.

When the possibilities and advantages of industrial appropriation of the results of pure science are in a degree realized from tangible results and the broad highway leading to them prepared and thrown

open to all traffic, many interesting relations are revealed that are not directly recognized as those of pure physics. By way of suggestion, the following from Pasteur may be of interest:

> Science it is true is of no nationality . . . yet it is the highest personification of nationality. Science has no nationality because knowledge is the patrimony of all humanity—the torch that gives light to the world. Science should be the highest personification of nationality, because of all the nations that one will always be foremost that shall be first to progress by the labors of thought and intelligence.

F. W. STEVENS

WASHINGTON, D. C.

ARTHUR ARTON HAMERSCHLAG

ARTHUR ARTON HAMERSCHLAG, born in Nebraska, was a native of the West, educated in the East, honored for his work by university degrees and society fellowships. He was perhaps most widely known for his advancement of trade and technical educational methods, culminating in the presidency of the Carnegie Institute of Technology at Pittsburgh for a period of twenty years.

With the advent of the world war he gave his technical services to his country as advisory assistant to the Secretary of War. At its close he returned to technical engineering investigations as president of the Research Corporation of New York, a service closed by death on July 20, 1927, at the age of fifty-eight years.

Thus ended a life characterized by breadth of vision, tempered by scientific honesty, keen insight, careful judgment, deep concentration, the results of an analytical mind and ripe scholarship.

He made scientific studies of commercial problems which have added to industrial progress, and his advice was sought in many fields. His life was a busy one and many of his studies required a large outlay of time and patience to unravel. Yet, with all his duties and urgent demands on time, he was never too busy to give counsel and advice to young men. This phase of his activities is known to those directly affected, but not to the outside scientific and industrial world, where his technical attainments were so well recognized.

These young men were encouraged to do their best work, to seek advancement on merit. Their problems were discussed from all angles and solution reached, just as in his work for industrial companies. They reported to him at regular intervals on their work and progress. The advice was given in personal interviews and even more by correspondence, usually by return mail. The number of these men would run probably into the hundreds during his lifetime.

The results are shown in the high positions in the industrial world now held by these protégés of Dr. Hamerschlag. They serve as executives, superintendents, etc., in some of the largest industries. They owe to a very large extent their progress and acknowledge their success as due to this influence.

He appeared to take a special delight and pleasure in these reports and in the advancement of these men. He delighted in sketching their upward rise in business, though seldom giving the name of the man.

Scientific and technical attainments survive and become part of knowledge and science, but the personal influence of a great and helpful man becomes part of life and character. Character building is as important, if not more so, than scientific growth, but when both are combined, that man becomes notable.

In a world beset with complexities, worry, toil, the lightening of the load by encouragement and helpful advice to the discouraged is a real humanitarian service.

Dr. Hamerschlag was a great engineer and educator; he was also a most valuable adviser and spur to greater endeavor to many young men who will miss his help, but who have become better and more successful men by his life, and who are very glad to pay this tribute to his memory.

G. P. GRIMSLEY

BALTIMORE, MD.

SCIENTIFIC EVENTS

CENTENARIES OF 1927

IN the London *Times,* as quoted in *Nature,* Professor H. J. Spooner directs attention to some of the notable centenaries which occur this year. Among the names of men of science which he mentions are those of Newton, Laplace, Fresnel, Volta and Lister. The bi-centenary of the death of Newton will be celebrated at Grantham in March, while the centenary of the death of Volta is being recognized by the holding of an electrical exhibition at Como. The custom of commemorating such events should find general acceptance, for, as Fairbairn once remarked, "the smallest honor we can do the great benefactors of mankind is occasionally to bring them to our recollection." To the names mentioned others are added by *Nature,* which says: "Next in interest to mathematicians and astronomers, after Newton and Laplace, comes that of Robert Woodhouse (1773–1827), successively Lucasian professor and Plumian professor, to whom belongs the credit of introducing the calculus at Cambridge and who found earnest disciples in Babbage,

Herschel and Peacock. Another astronomer who died the same year was Calandrelli (1749–1827), once director of the Vatican Observatory, while going back four hundrd years we have the birth of Stadius (1527–1579), a predecessor of Kepler as mathematician to the Emperor of Germany. A contemporary of Stadius who should not be overlooked was the famous Dr. John Dee, alchemist and astrologer, who was born in 1527 and died in 1608. To chemists and physicists the tercentenary of the birth of Boyle (1627–1691) and the centenary of the death of Augustin Jean Fresnel (1788–1827) will afford the greatest interest. Though Fresnel sank into an early grave he was one of the foremost students of optics, and it was only eight days before his death that Arago placed in his hands the Rumford medal of the Royal Society. Another physicist of note who died in the same year was Chladni (1756–1827), whose works on sound were translated into French through Napoleon. Henry Beaufoy (1764–1827) was both physicist and astronomer, but is still better known for his experiments in naval architecture. The year 1827 saw the publication by Ohm of 'The Galvanic Circuit worked out Mathematically.' Although no great chemist died in 1827, in that year were born Sir Frederick Abel (1827–1902), John H. Gladstone (1827–1902), Edward Nicholson (1827–1890) and, most distinguished of all, Marcellin Berthelot (1827–1907). In the same year the death occurred of Samuel Crompton (1753–1827), whose work as the inventor of the spinning mule will be the occasion of a gathering at Bolton, and also of George Medhurst (1759–1827), one of the inventors of the atmospheric railway. Among the great pioneers of last century was Sandford Fleming (born 1827), who was engineer-in-chief of the Canadian Pacific Railway from 1871 until 1880."

THE SEISMOLOGICAL WORK OF THE U. S. COAST AND GEODETIC SURVEY

THE most comprehensive survey of earthquakes of the United States, including the insular domain, ever undertaken by the government, is being compiled by the Coast and Geodetic Survey under the supervision of the director of the survey, E. Lester Jones.

The data are being compiled by the chief of the Division of Terrestrial Magnetism and Seismology, Commander N. H. Heck, to show the history of all the major disturbances that have been recorded on seismological instruments in United States territory, some cases dating back approximately a century. This information will be embodied in a compendium which will appear in the autumn telling the story of the principal earthquakes in both technical and non-technical language, with a short résumé of the scientific data, grouped by states and sections of the country as well as chronologically arranged.

The survey has recently completed its seismological report for October, November and December, 1925, with supplemental data to complete the record for 1924, and it has begun work for the official complete detailed record of 1926.

The 1925 report, prepared by the mathematician of the Division of Terrestrial Magnetism and Seismology, Frank Neuman, with the assistance of Lieutenant J. H. Service, Ensign F. B. Quinn and J. D. Thurmond, junior engineer, shows that out of 13 earthquakes recorded in United States domain from October 1 to December 31 of that year, the locations of the disturbances were well known or approximately known in 83 cases and uncertain or unknown in the other 54 cases.

The distribution of these known locations of earthquakes, by states, follows:

California, 17; foreign and submarine, 40; Mexico, 6; Wyoming, 4; Guam, 3; Connecticut, 3; Montana and Nevada, 2 each; Alaska, Hawaii, Maine, New Hampshire, Rhode Island, Washington (State), 1 each.

During that three months' period, seismographs formerly in operation at Vieques, Porto Rico, being thoroughly overhauled, were put in operation in the new Coast and Geodetic Survey magnetic and seismological observatory near San Juan, Porto Rico.

The surveys designed to detect earthquakes in California were continued during that period and a party, under the direction of William Mussetter, operated in the vicinity of the western end of the Santa Barbara channel.

Vessels engaged in survey work are directed to make reports of visible or felt effects of earthquakes, but none were reported by them and examination of tidal records from the numerous gauges on the Atlantic and Pacific Oceans disclosed no indication of tidal waves during the three months.

The complete seismological summary for 1925 showing "distribution of earthquakes recorded in the United States, the regions under United States jurisdiction and adjacent sections," enumerate 568 earthquakes so recorded during the year 1925, of which 222 were definitely or approximately located (locations officially described as "well-known or approximately known"), locations of 77 being listed as uncertain and locations of 269 as still unknown.

Of these 568 earthquakes, 130 were "provisionally located" as occurring in North America and 43 with some uncertainty in North America; 4 provisionally and 1 uncertainly, in South America; 3 provisionally in Europe; 11 provisionally, and 1 uncertainly,

Asia; 7 in the Atlantic Ocean and adjacent water, provisionally; 60 provisionally, and 32 uncertainly, in the Pacific Ocean and adjacent waters; 7 provisionally in the Indian Ocean, and adjacent waters; 269 unknown.

THE AERIAL SURVEY DETACHMENT

Two aerial survey detachments, each composed of a commissioned officer of the Army Air Corps, who is a photographic pilot, and an enlisted photographer, were recently authorized by the War Department, for the purpose of assisting the U. S. Geological Survey in carrying out its extensive program for the present calendar year in mapping areas in various states throughout the country.

One of these detachments will photograph areas in Maine, New Hampshire and Vermont, approximating 8,000 square miles. A great portion of these areas, particularly in Maine, have never been adequately mapped, and all existing are old and somewhat obsolete. The other detachment will begin operations on a 4,000 square mile area in Illinois, and later will photograph areas in Michigan and Wisconsin.

One detachment of this kind, organized last year for a like purpose, photographed during a six months' period approximately 9,000 square miles of territory in the states of Michigan, Wisconsin and Illinois. Through the work of this detachment it is estimated that the saving to the government was approximately $100,000, thus demonstrating the efficacy and economy of aerial surveying.

Each aerial survey detachment is equipped with trilens camera and accessories, and furnished with two special photographic planes, one of which is held in reserve. The function of these detachments is to make aerial photographs, which are in turn used in making topographic maps by the Geological Survey. The personnel of the detachments is relieved of all other military duties and assigned exclusively to aerial survey activities for a period of six months. It is placed under the direct control of the chief of Air Corps, who is authorized to issue the necessary orders, for its movements and employment, according to the program submitted by the survey.

THE CHEMICAL EXPOSITION

FROM the advance information which has reached *Industrial and Engineering Chemistry,* it may be announced that

Many distinctively new and outstanding achievements in chemical engineering, in the manufacture of instruments of precision, in mechanical engineering as applied to the chemical industry, in new apparatus of various and sundry kinds, and, we are happy to say, in new chemicals and new chemical products, will feature the Eleventh Exposition of Chemical Industries, which will open its doors to the public on September 26 at the Grand Central Palace, New York City. There will be an extensive exhibit of casein plastics, some of which are new in the field and deserve careful examination. Alloys especially high in their resistance to corrosion will be another point of interest, for some of them have been offered only lately following a considerable period of research. One of the great corporations which has not been prominently identified with this development has recently undertaken some new lines of manufacture, the products of which will be seen at the exposition.

This year in a section devoted largely to exhibitors of containers, emphasis will be placed upon packaging, weighing, labeling and handling equipment. The subject of containers has long been a troublesome one, for in the past many products of the chemical industry have been marketed in such disreputable packages that attention was directed to the matter some time ago. Not only is the use of such packages detrimental from the sales point of view, but in some instances the common carriers have refused to accept some commodities for transportation, not primarily because of their hazard, but chiefly because of the carelessness in methods of packing. This unfortunate situation is now much relieved and the exhibits to be found this year at the exposition will prove of great assistance to chemical manufacturers.

Among the exhibits will be found many of distinctly educational nature. These include those under the auspices of the American Ceramic Society, the American Chemical Society, the National Safety Council, several bureaus of the United States Department of Commerce and the United States Department of Agriculture. Several industries will use the opportunity to promote the education of the public with reference to their products, as for example, the new types of glass which permit a large percentage of the active rays of the sun to pass through them. Iowa State College will present evidences of development in the industrial use of agricultural products. From the territory represented by such railroads as the Southern and the Southern Pacific Company, and from the Ontario Department of Mines will come interesting displays of natural raw materials from the field as well as from the mine. The southern section will include a considerable number of exhibitors, part of which will represent commercial houses and large industries. Some three hundred exhibitors are upon the list of those who have engaged space.

SCIENTIFIC NOTES AND NEWS

BERTRAM BORDEN BOLTWOOD, since 1910 professor of radio-chemistry in Yale University, died by suicide on August 14, at the age of fifty-seven years.

FRIENDS of Mr. Thomas A. Edison and employees of the Edison interests throughout the country joined on August 8 on the lawn of Edison's home at Llewellyn Park, West Orange, N. J., in honoring the inventor, who fifty years ago completed the first mechanism for

recording and reproducing sound. Governor A. Harry Moore, of New Jersey, was among the guests and presented to Mr. Edison a bound portfolio of letters of felicitation received from prominent men and women throughout the world.

DR. CHARLES ATWOOD KOFOID, chairman of the department of zoology at the University of California, has been elected president of the Pacific Division of the American Association for the Advancement of Science; Dr. Joel H. Hildebrand, professor of chemistry, and Dr. Leonard B. Loeb, associate professor of physics, have been appointed members of the executive committee.

ON the occasion of the meeting of the British Association for the Advancement of Science, the University of Leeds will confer the doctorate of laws on Sir Arthur Keith, president of the association; on the Duchess of Atholl, and on the Hon. Sir Charles Parsons, and the doctorate of science on Dr. J. B. S. Haldane, Dr. N. V. Sidgwick, Dr. F. O. Bower and Dr. R. A. Millikan.

THE fifth gold medal of the African Society, instituted for those who have done the best work for Africa, has been awarded to Sir Ronald Ross, director-in-chief of the Ross Institute and Hospital for Tropical Diseases.

M. CHARLES FABRY, professor of physics at the Sorbonne and director of the institute of optics of the University of Paris, has been elected a member of the Paris Academy of Sciences in the section of physics to succeed the late M. Daniel Berthelot.

M. GRAVIER has been appointed a delegate of the Paris Academy of Sciences to the International Congress of Zoology, which will open in Budapest on September 9.

DR. EMMELINE MOORE, of New York, was elected president of the American Fisheries Society at its recent convention at Hartford, Connecticut. Other officers elected were C. F. Culler, of the U. S. Bureau of Fisheries, *vice-president;* Carlos Avery, secretary of the American Game and Protective Association, *secretary,* and T. E. Pope, of the Public Museum of Milwaukee, *treasurer.* Next year's meeting will be held in Seattle, Washington.

DR. F. L. CAMPBELL, assistant professor of biology in New York University, has resigned to accept a position as associate entomologist in the Bureau of Entomology, Washington, D. C., where he will investigate the toxicology of stomach poison insecticide.

J. D. RUE, chief of the pulp and paper section of the U. S. Forest Products Laboratory, will leave the laboratory about September 15 to take the position of director of research for the Champion Fibre Company, of Canton, N. C. Mr. Rue has been in charge of the pulp and paper section of the Forest Products Laboratory since 1921.

DR. PETER H. BUCK (TE RANGI HIROA), director of Maori Hygiene for the New Zealand Government, has been appointed anthropologist on the staff of Bernice P. Bishop Museum, Honolulu. During 1927–28, Dr. Buck plans to give his attention chiefly to investigations in the Cook Islands, in continuation of previous studies. Gerrit P. Wilder, botanist on the staff, has returned to the United States after a year's study of the breadfruit trees in the Society and Cook Islands. Mr. John W. Gillespie, Bishop Museum fellow in Yale University, is making a botanical survey of Viti Levu, Fiji, with especial attention to the flora of high altitudes. In this investigation, he is associated with Mr. H. E. Parks, of the University of California, who has been at work in Fiji for the past three months. Mr. H. G. Hornbostel, who for the past three years has been engaged in archeological field work in Guam and the Marianas Islands, under the auspices of the museum, has begun similar studies in the Caroline Islands.

DR. WALTER H. EDDY, professor of physiological chemistry at Columbia University, has returned from a half year's leave of absence which he spent in Spain, France, England, Barbadoes, Trinidad, Costa Rica, Panama and Cuba.

DR. CALVIN O. ESTERLY, for twenty years professor of zoology in Occidental College, has been granted a leave of absence for the academic year 1927–28. Dr. and Mrs. Esterly plan to go to Hawaii in August.

H. S. LADD, of the University of Virginia, is engaged in studying the fossil mollusks of the Fiji Islands and will later spend about a month at the National Museum.

H. D. SKINNER, of the department of anthropology of the University of Otago, Dunedin, New Zealand, was recently the guest of the Pueblo Bonito Expedition of the Smithsonian Institution.

DR. JAMES MUIR, radium therapist, sailed for Europe on August 6 to read papers and give clinical demonstrations on his treatment of cancer by radium implantation at the four leading European capitals.

LEAVE of absence has been granted to Dr. Arthur H. Compton, professor of physics of the University of Chicago, from October 1 to November 10, in order that he may attend the Solvay Congress, and to Derwent S. Whittlesey, associate professor of geography, for the autumn, winter and spring quarters, 1927–28, in order that he may take charge of the work in geog-

raphy on the second round-the-world cruise to be conducted by New York University.

DR. EDWIN G. CONKLIN, of Princeton University, recently lectured at Columbia University on "Heredity *versus* Environment in Human Progress" and on "Some Common Misconceptions regarding Evolution," and at the Mount Desert Botanical Laboratory in Maine on "The Evolution Controversy in the United States."

DR. FRANCIS G. BENEDICT, director of the nutrition laboratory in Boston of the Carnegie Institution of Washington, gave an address at the University of New Hampshire, recently, on "Physiologic Research Institutions of Europe."

DR. ALEXANDER CROMBIE HUMPHREYS, for twenty-five years president of the Stevens Institute of Technology, well known as a gas engineer, died on August 14, aged seventy-six years.

LOYALL VERGIL HUNT, B.S., Kansas State Agricultural College, 1923, student assistant in zoology at West Virginia University, was drowned on August 7 while bathing in the Cheat River near Morgantown.

SIR BRYAN DONKIN, honorary member of the Royal Medico-Psychological Association, and author of many publications on criminology and related subjects, died on July 26, aged eighty-two years.

DR. ALBRECHT KOSSEL, professor of physiology in the University of Heidelberg, known for his contributions to our knowledge of the chemical nature of the proteins, died on July 5, aged seventy-four years.

DR. PAUL KESSLER, associate professor of geology at the University of Tübingen, died on July 14.

THE United States Civil Service Commission announces open competitive examinations to fill vacancies in the U. S. Department of Agriculture as follows: Junior crop and livestock estimator, in the bureau of agricultural economics, for duty in Washington, D. C., or in the field, at $1,860 a year, and associate dust explosion prevention engineer at $3,000 a year, and assistant dust explosion prevention engineer at $2,400 a year, in the bureau of chemistry and soils.

IT is reported in the *Journal* of the American Medical Association that the residents of Pine Grove are seeking an injunction to prevent the establishment in that community of a research laboratory by the state of Montana for the purpose of investigating the prevention of Rocky Mountain spotted fever, it being reported that they have instituted court proceedings, making members of the state board of health the defendants. Dr. William F. Cogswell, secretary of the state board of health, testified on July 29 that there would be no chance for the experimentally infected ticks to escape from the proposed laboratory. The question of how fast these ticks travel is said to have enlivened the court proceedings.

THE Illinois State Geological Survey has recently received from the legislature, with the approval of the governor, an increased appropriation, which will permit an extension of specialization in petroleum engineering and geological engineering and the undertaking of a comprehensive paleobotanical study of the Pottsville series, in addition to its regular program of stratigraphic, glacial and economic studies. The paleobotany of the Pottsville series will be studied by Dr. David White. The previous appropriation of $50,000 per year for topographic mapping was continued.

THE topographic maps made by the Geological Survey of the Department of the Interior show by means of contour lines, of which there are thousands on some maps, the altitude above sea-level of every portion of the area represented. In addition to portraying all physical characteristics, as well as the works of man, these maps constitute a wonderfully detailed dictionary of altitudes, showing the height of every hill and slope. As the United States becomes more and more completely mapped, the scope of this "dictionary" constantly expands. At the present time a little more than 40 per cent. of the United States is topographically mapped, but the work is progressing rather slowly at the rate of only 17,000 or 18,000 square miles a year. Moreover, the maps of a large part of this area are either very old, and therefore somewhat crude, or else on so small a scale as to be inadequate for present-day needs. In addition to areas that have never been surveyed, there are considerable areas that will have to be resurveyed.

WE learn from *Nature* that in *Man* for July, Professor Frassetto, of Bologna, figures and describes his reconstruction of the jaw of Piltdown man, which he compares and contrasts with the jaws of the orang and the chimpanzee. In his view its resemblance lies in the direction of the orang rather than that of the chimpanzee. He gives in tabular form eight points in which the orang differs from the chimpanzee, and in which the jaw of Piltdown man, so far as its condition allows, is comparable with it. As a whole, the jaw of the chimpanzee is relatively thin, slight and light, while both orang and Piltdown are massive and heavy; the ascending ramus is oblique in relation to the horizontal portion, but in the orang and Piltdown almost vertical; the position of the semilunar notch coincides in the two jaws, but in both differs from its position in the chimpanzee jaw; the angle has a curvature of a large radius in orang and Eoanthropus, but it is small in the chimpanzee; the posterior margin of the chimpanzee ramus is narrow to the root of the

condyle, where it widens rapidly, but in both the other jaws it widens gradually as it passes into the condyle. Again, the lower borders of the corpus of the mandible resemble one another in both orang and Piltdown, but differ from the chimpanzee, which also has a relatively small genial fossa as opposed to the large fossa of the other jaws. The reconstruction was therefore made by grafting the symphysian region of the orang's mandible duly enlarged on to the corpus of Piltdown man's jaw, the conclusion being that the jaw is human, belongs to the same individual as the cranial fragments, and represents a primitive race belonging to a genus of the orang type. Not only is this because of the features of the mandible, but also because of the eyebrow ridges, which do not exhibit the prominent torus characteristic of the chimpanzee type to which Neanderthal man belongs.

THE results of an investigation into certain processes and conditions on farms undertaken by Mr. W. R. Dunlop, under the auspices of the National Institute of Industrial Psychology, are reported in *Nature* as follows: "These results show that farm management in Great Britain is by no means efficient. The present investigation is the first systematic attempt in Great Britain to apply the point of view and methods of industrial psychology to agriculture. Two problems were studied: (*a*) the picking and packing of fruit, including bush fruit, hops and glass-house produce, and (*b*) milking. It is shown that the best pickers at one kind of fruit are the best pickers at all other kinds, that there is no evidence to show that afternoon rates are lower than those of the morning, that there are considerable individual variations in efficiency. The milking problems include discussions of milking rates, differences of cows, manual skill of milkers. Some important questions are raised in the third section dealing with future enquiries, not the least of which is the selection of the right worker for the right work, and the guidance of young people leaving school into occupations for which they are most fitted. Apparently there is a tendency for the children of a lower level of intelligence and ambition to take up agriculture, the town attracting the more intelligent. In so far as this is so, it is to be deplored, but obviously the problems connected with such a choice are very difficult to attack, involving as they do the attitude of mind of the community towards agricultural work, the lower standard of nominal wages and the ties with regard to hours."

UNIVERSITY AND EDUCATIONAL NOTES

BY the will of the late Dr. Charles A. Dewey his estate of nearly $1,000,000 is to be held intact as the Charles A. Dewey Fund, the income to be devoted to the support of the medical schools of the University of Rochester and of Harvard University. Dr. Dewey graduated from the University of Rochester and from the Medical School of Harvard University in 1880. In addition to the foregoing provision, which became effective through the recent deaths of a nephew and niece, the will provides a gift of $100,000 to the Rochester General Hospital as a memorial to Dr. Dewey's sister.

As a result of a decision handed down by John P. O'Brien, surrogate of the New York County Court, Dartmouth College eventually will receive $373,024 from the estate of Mrs. Helen L. Bullard. The will had been contested on the ground that the decedent estate law prohibits the payment of more than one half of an estate to charitable or educational institutions when there are immediate members of the family living at the time of the passing of the testator. It was ruled that the value of the Dartmouth remainders should be computed at the time of the death of Mrs. Bullard upon the life expectancy of the thirteen life tenants as shown in insurance tables.

DR. RAYMOND M. HUGHES, for sixteen years president of Miami University at Oxford, Ohio, has resigned to accept the presidency of the Iowa College of Agriculture and Mechanic Arts at Ames.

AMONG the promotions to full professorships announced by the University of Chicago Board of Trustees are the following: Ernest W. Burgess, in sociology; Fay-Cooper Cole, in anthropology; Arthur J. Dempster, in physics; Edward Sapir, in anthropology; William Taliaferro, in pathology, and Louis Leon Thurstone, in psychology. Promotions to associate professorships include: Merle C. Coulter, in botany; Maude Slye, in pathology, and Benjamin A. Willier, in zoology.

DR. W. MANSFIELD CLARK, of the Hygienic Laboratory of the U. S. Public Health Service, Washington, D. C., has accepted the position of professor of physiological chemistry at the school of medicine of the Johns Hopkins University.

DR. THOMAS MURRAY MACROBERT, university lecturer in the University of Glasgow, will succeed Dr. Gibson as professor of mathematics.

DR. ERWIN SCHRÖDINGER, of the University of Zurich, has been called to the University of Berlin as the successor of Professor Max Planck.

DR. REINHARD DEMOLL, director of the biological laboratory at the University of Munich, will succeed Dr. Karl Grobben as professor of zoology in the University of Vienna.

DISCUSSION

THE QUANTITATIVE THEORY OF SEX

IN a recent note in SCIENCE (Vol. 65, p. 596) Dr. R. Goldschmidt comments on an earlier communication in which the present writer (SCIENCE, Vol. 65, p. 139) questioned the completeness of Dr. Goldschmidt's proprietary rights to "The Quantitative Theory of Sex"—as claimed or implied in his initial request for "acknowledgments" from the "Columbia school" (SCIENCE, Vol. 64, p. 299). It was our purpose to point out that "Goldschmidt can properly claim precedence" in the elaboration of "a quantitative theory of normal sex determination," but not for "the quantitative theory of sex as this has developed during the last fifteen years." In his reply Goldschmidt not only fails to assist in the clarification of this essential point, but he turns the discussion to fragments—considered by him as wholes—of various aspects of the work of Riddle which, he is distressed to find, afford "no proofs" of either "experimental intersexuality or experimental sex-reversal." The original point is a matter of interest to a relatively large group of workers, and some of his misstatements concerning studies made in our laboratory require a word of comment.

Quite apart from any question of the adequacy of supporting facts, and wholly irrespective of whether one or a dozen workers obtained the results upon which the theory is based, it is simply a fact that a quantitative theory of sex exists apart from, and was founded before, any theory of Goldschmidt's on quantitative sexuality. Further, it is a fact, sufficiently known to workers in this field, that the present writer has taken a not negligible share in the formulation of this theory, being specifically responsible for a series of views concerning the relation of metabolic rate to sex: Namely, that such a difference extends to the two kinds of gametes produced by the heterogametic sex; that here the prospectively male gametes show the higher, female gametes the lower metabolic rate; that a difference in this same direction also characterizes later (embryo and adult) stages of the development of sex; that such metabolic differences can, in experiment, override the normally controlling influence of the chromosomes—thus resulting in the sex-reversal exhibited in several animal forms; that the sex chromosomes or genes probably exercise their normal sex-determining function by aiding the establishment of a higher and a lower metabolic rate; that intersexes and hermaphrodites can arise from chromosomal or genic causes, but they can arise also from a metabolic cause while chromosomes and genes are normal; and that the metabolic distinction found can not be interpreted as a secondary sex character.

The evidence on which this theory is based has, practically from the beginning, rested on the results not only of Whitman-Riddle in doves, but those of the Hertwig school on frogs, of G. Smith on crabs, and still other work. It included the much older facts and idea of Geddes and Thomson, and had indeed such a background of varied and promising fact that it is little wonder that the great advances since made—including some more recent and still unacknowledged interpretations of Goldschmidt—have definitely turned in this direction.

In his book, Goldschmidt (1923, p. 116) says: "In the case of insects intersexuality could only be obtained through abnormal zygotic constitution, because the production of hormones is not localized in special organs, but takes place within the individual cells. In the other group (vertebrates) it is possible to obtain intersexuality independent of the zygotic constitution because the hormone production is localized in organs which can be removed or transplanted, and their action independently of the zygotic constitution which originally called them forth can in this way be investigated." If then intersexuality in insects—with which Goldschmidt worked—can only be obtained by "abnormal zygotic constitution" (hence, no plasticity here), are we not correct in placing Goldschmidt's results as important to the theory of "sex-determination," and "unimportant to the quantitative theory of sex as this has developed in the hands of others" (in whose vertebrate material plasticity is found)? Truly enough, "some of Riddle's arguments are based on work in hybridizing doves" but we think —though very erroneously, says Goldschmidt—we find a plasticity in a part of our vertebrate material indicating that one and the same zygotic constitution here does not deliver equivalent sexuality but varies according to identifiable conditions; and we have measured the concurrent gametic metabolic change that coincides with this plastic change of sex. Goldschmidt's results fall far short of this (since by his own admission "intersexuality could only be obtained through abnormal zygotic constitution"), and for this reason—not because "they happen to be found by Goldschmidt" instead of by Riddle—his results are unimportant to the quantitative theory of sex now under discussion.

The different gradations in sex behavior produced and measured by us in doves are entirely discarded by Goldschmidt as evidence of intersexuality. He wants "morphological" mixings. After wondering how, on Goldschmidt's view, psychologists and psychiatrists could ever become acquainted with "sex" in their fields—and leaving the question to our colleagues and the future—we may note that Goldschmidt should read more and better before suggesting that graduated intersexual behavior is "the only fact" provided by us for intersexuality. We freely

admit that we have thus far given only short and incomplete accounts of the many kinds and cases of intersexuality encountered in our material. We acknowledge and regret, and are steadily supplementing, this incompleteness. But morphology, beloved of Goldschmidt, is I presume adequately represented by oviducts in males (*Anat. Rec.*, 1925, 31, p. 349); by persistent, even functional, right ovaries in females (*Amer. Nat.*, 1916, 50); and by the hermaphrodites listed (Whitman, 2, 1919), or referred to in connection with rather full descriptions of some other abnormal (possibly not intersexual) gonad conditions (*Brit. Jour. Exp. Biol.*, 1925, 2). If these, as yet little described, cases of hermaphroditism should lead our critic to dispose of them by the further assertion that Riddle can not properly recognize an hermaphrodite he is entirely welcome to that position.

Goldschmidt states that our "claim to the experimental production of sex-reversal by reproductive overwork and by crossing . . . is based on the assumption that the first egg of a clutch is male, the second female." This is simply not true. "Our studies on 'sex control' manage to get on whether the eggs come in normal order, reversed order or utter disorder" (*Amer. Nat.*, 1925, 59). Also, according to Goldschmidt we have "never proved experimental sex-reversal or made it even probable." Waiving the large question of proofs, we may note that calculation of probabilities in a single result obtained in one of our very few "family" crosses indicates that—apart from sex-reversal—this result "could be expected to occur only once in 9,384 trials" (*Anat. Rec.*, 1925, 31). So apparently, either Goldschmidt must read more, or in my items of data I must eliminate part of *one* chance in 9,384.

To say that "Riddle's theory of sex determination by different metabolic rates . . . fails in the normal case of male heterogamety; it fails in such cases of female heterogamety as the gipsy moth, etc.," is merely to use words without meaning. The theory was founded upon forms showing "female heterogamety" (pigeons), and early applied, successfully we think, to forms (frogs) which later proved to show "male heterogamety"; moreover, as earlier pointed out, parts of this metabolic theory were later borrowed and lugged unacknowledged into Goldschmidt's own theory of sex-determination in the gipsy moth.

Well or ill founded—and much in addition to work with pigeons forms part of its foundation—there exists a vigorous quantitative theory of sex, based on real or fanciful sex-reversal and intersexuality apart from zygotic composition (on which Goldschmidt's studies are based), and on measurements of metabolic sex distinction in all stages—ovum to adult. We and others have taken a good or a bad part in all this, and the quantitative theory of sex can not be properly discussed—as Goldschmidt would have it—as the private affair of the "Columbia school" and the laboratory of Goldschmidt.

OSCAR RIDDLE
CARNEGIE STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, L. I.

ZOOLOGICAL NOMENCLATURE

REFERRING to the recent referendum on Dr. Poche's (Vienna, Austria) three propositions in regard to the Rules of Zoological Nomenclature, the undersigned has the honor to report to the zoological profession the following results of the ballot:

Poche's proposition I: 8 votes for; 549 votes against.
Poche's proposition II: 4 votes for; 550 votes against.
Poche's proposition III: 4 votes for; 551 votes against.

A detailed report will be made to the Tenth International Zoological Congress (Budapest) and the undersigned unreservedly accepts the unambiguous results of this referendum as definite instructions from the profession in the United States for him to cast his vote (in the congress as delegate, and in the commission as member) against all three propositions.

C. W. STILES,
Professor of Zoology, U. S. Public Health Service

"OPALINA ELONGATA" GOURV. IS CEPEDEA SAHARANA METCALF

V. GOURVITSCH describes as new an Opalinid from *"Rana ridibunda"* from Tashkent, Turkestan.[1] He names this *"Opalina elongata."* It is a *Cepedea* and from his description seems to be the form I have described as *Cepeden saharana* from *Rana esculenta ridibunda* collected at Biskra, Algeria.[2] It seems well to call attention to this to prevent confusion.

MAYNARD M. METCALF

QUOTATIONS

PUBLICITY AND SCIENCE

IN this day of personal horn-blowing it is refreshing to come upon a group of men who are doing great things, yet who shun publicity as they would the plague. As a matter of fact, they would not shun the

[1] V. Gourvitsch: The protozoan fauna of the intestines of frogs from the vicinity of Tashkent—in the *Bulletin* of the Government University of Central Asia, No. 14, 1926. [Russian.]

[2] M. M. Metcalf: "The Opalinid Ciliate Infusorians," United States National Museum, No. 120, 1923.

plague. They are engaged in a fight against cancer, which is far more persistent and no less deadly.

There was an account in Thursday's *Evening Post* of the work accomplished by physicians of the Memorial Hospital, to which Edward S. Harkness recently gave $250,000 for the purchase of four more grams of radium. From this publicity Dr. James Ewing, director of cancer research at the hospital, shied as though one were asking him to give a trapeze performance. About a year and a half ago, when the new treatment was first announced in the press, Dr. Herbert A. Quick, who has directed its application and has had much to do with its development, is said to have acted as though he were being disgraced. Mr. M. Failla, the laboratory worker whose suggestion it was that gold instead of glass be used in the "seed" tubes now implanted in cancerous growths—a vital element in the new treatment never before has been publicly mentioned in connection with the discovery. Nor has Dr. Max Cutler, who first worked out the problem on animals before it was applied to human beings.

There is a deep-seated prejudice against publicity, the heritage of many of the ablest men in the medical profession, which plays its part in the suppression of information which should be presented to the public. One of the most important reasons for this feeling lies in the constant flood of "claims" which second-rate scientists make of "discoveries" and "cures." Some of these announcements are made through overenthusiasm and some through a desire to take advantage of the public's ignorance of science.

Hence the practice has grown up among men of science of not making public announcements of their findings until they have been presented before groups of leading men in the profession, who can discuss and criticize them in the full light of scientific knowledge before the public is informed. This is a wholesome procedure. But the fear of publicity is carried too far when leading men are afraid to speak for publication even after their work has been tested in the scientific society's conferences and in the laboratories of coworkers, simply because they fear criticism from members of their own profession.

It is largely because of the reticence of the men best qualified to speak that those not nearly so well qualified occupy so much of the newspaper space devoted to science. It is also partly because of this reticence that publicists have conceived the notion that the public wants its science information jazzed up and distorted. The public never was so hungry for authentic information as it is to-day. If men of science were to speak freely where they find a disposition to report news of science sanely an *entente cordiale* between science and journalism would be established which would be of inestimable value to both—and to the public.—*New York Evening Post.*

SCIENTIFIC BOOKS

Collected Papers of Sir James Dewar. Edited by LADY DEWAR. Vol. I. 27×17 cm; pp. xxii+674. Vol. II. 27×17 cm; pp. ix+814. Cambridge and New York: The Cambridge University Press; The Macmillan Company, 1927.

To many chemists Dewar is known as the Englishman who specialized in low-temperature work and as the man who invented the thermos bottle. Only relatively few know much about his spectroscopic work in collaboration with Liveing and yet his high-temperature work began in 1872 and was continued up to 1889. Since the first low-temperature paper was published in 1884 and since Dewar was appointed Jacksonian professor of natural philosophy in the University of Cambridge in 1875 and Fullerian professor of chemistry in the Royal Institution of Great Britain in 1877, it is evident that he had made a distinguished name for himself before he ever started on low-temperature work.

New to most people will be the work on the physiological action of light, on electrophotometry, on capillarity and on the properties of nickel carbonyl. A good many people know that he collaborated with Moissan in studying the properties of liquid and solid fluorine.

What very few people realized, outside of his personal friends, is the surprising versatility of the man. When he studied low-temperature problems, for instance, he covered the whole range. It was not merely a question of developing improved methods of liquefying gases and of determining melting points, boiling-points, and densities. Dewar studied specific heats, latent heats of vaporization, diffusion, adsorption by charcoal, optical and magnetic properties, color, photochemical reactions, the effect of low temperatures on bacteria and on electrical resistance, etc., etc. It is a real pleasure to note how many sides Dewar saw to a problem. Everybody knows that Dewar was a marvelous manipulator; and this fact is impressed on the reader because, in these volumes, one runs the whole gamut in so short a time.

It is interesting to note Dewar's attitude towards physical chemistry as far back as 1888. "At the present time we may say that there are two large schools of chemistry: one school cultivating organic chemistry, in which structural or atomic building up of an atomic character is carried out on a gigantic or manufacturing scale, producing thousands of new bodies every year, and continually increasing in the energy of its work and the variety of its produc-

tions. On the other hand we have another school in which physical chemistry is predominant, where the physical relations of chemical action are minutely examined, and where the effect of the physical relations of the constituents taking part in chemical changes is being more and more elaborately studied," p. 307.

Physical chemistry, as Dewar used the term, started with Black whose early lectures were entitled "Lectures on the Effects of Heat and Mixture." "Black used to institute a parallel between the phenomenon attending the hydration of lime and that which occurred when steam was condensed to water, both being accompanied by an evolution of heat and a change of state. The one might be called a chemical change, but for him it was analogous to the simpler change of physical state involved in the other," p. 313.

"The chief idea [in the set of experiments made by van't Hoff] is to correlate concentration with varying gaseous density, so that the reactions of salt solutions are brought into harmony with gaseous reactions. This is the work which van't Hoff has attempted, and very remarkable it is to consider the concentration of a solution containing a certain quantity of a salt as if the substance was in the gaseous state, and prove that the pressure of the dissolved solid is practically the same as if it had been volatilized into the same volume. Thus a new view has been opened up which brings into harmony the whole question of solutions of varying concentrations and the laws regulating their reaction," p. 314.

In 1899 Dewar published a diagram, p. 687, showing that the extrapolated resistance of a platinum resistance thermometer is zero at about $-245°$ C., and he concludes that probably the resistance curve becomes practically asymptotic to the temperature axis. In 1902 he comes back to the subject in his presidential address to the British Association, p. 785. "All known liquids, when forced to evaporate quickly by being placed in the exhausted receiver of an air pump, undergo a reduction in temperature; but when hydrogen was treated in this way it appeared to be an exception. The resistance thermometer showed no such reduction as was expected, and it became a question whether it was the hydrogen or the thermometer that was behaving abnormally. Ultimately, by the adoption of other thermometrical appliances, the temperature of hydrogen was proved to be lowered by exhaustion as theory indicated. Hence it was the platinum thermometer which had broken down; in other words the electrical resistance of the metal employed in its construction was not, at temperatures about $-250°$ C., decreased by cold in the same proportion as at temperatures about $-200°$. This being the case, there is no longer any reason to suppose that at the absolute zero platinum would become a perfect conductor of electricity; and in view of the similarity between the behavior of platinum and that of other pure metals in respect of temperature and conductivity, the presumption is that the same is true of them also." This conclusion was unfortunate because Kamerlingh Onnes showed, some years later, that the electrical resistance of gold, mercury, and platinum vanishes at the temperature of boiling helium, p. 1103.

Dewar was once the victim of the misleading experiment. In 1873 he determined the vapor density of potassium in an iron vessel and found that the molecular weight corresponded to the formula K_2, p. 72. In 1879 he repeated the work, using the Victor Meyer method which had been described the year before. The molecular weight varied from 74.4 to 90.5 with a mean value of 81.6 as against 78.2 calculated for K_2. Sodium gave values varying from 40.9 to 63.6 with a mean molecular weight of 50.7 as against 46.0 for Na_2. "Four pieces of potassium weighed in iron capsules and thrown into water gave 84.2 as a mean molecular weight, calculated from the hydrogen evolved. Four pieces of sodium similarly treated gave 49.8 as a mean. The above experiments show that no great accuracy in the determination of the vapor-density of sodium and potassium can be attained by this method of working when vessels of wrought iron are employed. The results are, however, conclusive as regards the *normal character of their respective vapor-density*," p. 177. Later in the same year Dewar and Scott repeated these experiments, using a platinum vessel, getting mean molecular weights of 26.4, 25.8, and 24.9 for sodium, and of 44.0 and 40.7 for potassium. "The new determinations of the molecular weights of potassium and sodium are just about half the former values, and would seem to support the inference that the atom of each of these metals resembles mercury and cadmium in the gaseous state, as regards molecular volume. Such a remarkable result can not be accepted without a very thorough investigation of the secondary reactions which may be induced at high temperatures. It is certain that in the platinum vessels there is much less absorption of vapor than in the case of iron, and that the action of the furnace gases is all but eliminated," p. 183.

Under Pictet's experiments on the liquefaction of hydrogen, we read, p. 169, that "hydrogen in the liquid state at a temperature of $-140°$ has a pressure of about 320 atmospheres and appears to solidify in the tube when the fluid jet is allowed to escape. The jet of liquid has a steel blue color." The color was not surprising in those days when it was thought

that solid hydrogen was probably a metal. We know now that hydrogen is colorless both as solid and as liquid. Consequently the steel blue color was either due to an impurity or was a structural color.

In a paper on "The Coming of Age of the Vacuum Flask" in 1914, Dewar points out that as far back as 1873 a highly exhausted annular metallic vessel was used by him in calorimetric experiments. It was not until 1893, however, that he described the use of glass vessels. During the war the all-metal thermos bottle was developed, thus harking back to the original type.

While one can not fail to be impressed by the brilliancy and versatility of Dewar's work, it is surprising that there is so little in the way of theory. The truth of the matter seems to be that Dewar was what the reviewer has called an accumulator rather than a guesser. He was intensely interested in experimentation and he did not care at all for the theoretical bearing of the experiments. He did a good deal of work on adsorption of gases but he never cared about the laws of adsorption. This appears even more strongly in his work on soap films. The results are fascinating and are veritable triumphs of experimental ingenuity. Bubbles were blown four feet in diameter which lasted several hours; one bubble, 46 cm. in diameter, lasted sixty-three days; and a horizontal black film, 20 cm. in diameter, lasted for a year. Dewar gives all details; but he draws no theoretical conclusions from them and makes no effort to do so.

WILDER D. BANCROFT

CORNELL UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE GINS METHOD OF DEMONSTRATING CAPSULES OF BACTERIA

WHILE using the Burri India ink method of studying bacteria, especially for demonstrating the various forms of the diphtheria bacillus, the idea occurred of attempting the demonstration of capsules of bacteria through staining of the India ink films. The method was tried with excellent success. Subsequent search of the literature has shown that the method in all its essential details has been described previously by Gins.[1] Since the method has worked out very well in class use and does not appear to be generally known in this country, I am giving the technic for the information of others.

The ordinary India ink sold in this country for drafting purposes can be used for this purpose providing it is free of bacteria. This, however, was not the case in several samples recently purchased, there being large numbers of organisms present. An ink which is prepared especially for the purpose is that of Grübler, known as Pelikan tusche No. 541. This ink probably contains a preservative since bacteria have been absent in the samples examined.

The ink usually works better when it is diluted with an equal amount of sterile distilled water. A drop of the diluted ink is placed near one end of a very clean slide and a loopful of the bacterial suspension is carefully mixed with it. The mixture is then spread across the slide with the edge of a second as when making a blood smear. A properly made preparation should be uniformly spread and of a grayish color rather than black. After drying in the air, the film should be fixed by heating or preferably by dipping in methyl alcohol. The slide may now be stained with any of the ordinary bacteriological stains including the Gram method. If the film is too thick it sometimes loosens after fixation, but properly spread films seldom give any trouble in this respect. A cover-glass may be used to protect the film but such protection is not needed if the slide is carefully handled.

Under the microscope well-stained organisms can be seen lying in lacunae in the film of ink. The margin of the capsule is sharply delineated by the ink, and the margin of the bacterial cell is sharply delineated by the stain. Between the two is a clear space which represents the capsular substance. If the film of ink is too thick, shrinkage of the film may produce separation of the ink from the cell wall, thus giving rise to an artifact which resembles a capsule. When the ink is properly diluted this difficulty has not been met with.

This method has been used successfully in class work using the Friedlander bacillus, the anthrax bacillus and the pneumococcus as test organisms. The anthrax organism shows a thin capsule even in cultures which have been continuously in artificial media for many generations. A similar capsular substance has also been evident in the streptococcus cultures which have been examined by this method. These organisms do not show any evidence of capsular substance when examined by other capsule demonstrating methods and are not capsulated in the ordinary sense of the word. Apparently some sort of intercellular substance exists in all chain-forming organisms and it is this material which is demonstrated by this method.

WILLIAM A. HAGAN

N. Y. STATE VETERINARY COLLEGE,
CORNELL UNIVERSITY

[1] Centralbl. f. Bakteriol., Parasitenk. u. Infektionskrankh. Abt. I Orig. 1911, Bd. 57, 477.

RESEARCH NOTES FROM THE HARVARD OBSERVATORY

New star in Sagittarius. In the constellation Sagittarius, the "home of galactic novae," a new star has recently been found by Miss Gill, on photographs made at Arequipa, Peru. It appeared suddenly at the eighth magnitude on June 22, 1924, and during the succeeding three months, in the ordinary course of the sky patrol, was unknowingly photographed seventeen times as its light steadily decreased beyond the range of the Arequipa telescopes. The star fails to appear on some fifty patrol photographs of the region made since September, 1924, and it is also completely absent from more than three hundred photographs of the region extending throughout the twenty-five years preceding its outburst.

Of the fifty or so galactic novae, nearly twenty have been discovered on Harvard plates of Sagittarius and the immediately surrounding constellations. The high concentration of catastrophes in one region is due, I believe, to the fact that these constellations lie in the direction of the center of the Galaxy and provide, therefore, a deep hunting ground for novae. An alternative explanation of the frequency of novae depends on the abundance of dark nebulous clouds that might contribute to the explosive unbalancing of involved stars; but such nebulosities are numerous in other parts of the sky where novae are rarely or never found.

Cosmic rays. The source of penetrating radiation is a problem that is exciting considerable attention of physicists and astronomers just now—perhaps too much attention, for in some quarters the actual existence of the highly exciting cosmic rays is yet doubted. The measures by Kohlhörster and others in Europe of the intensity of the radiation and of its variations from day to day and hour to hour are not in too good agreement with results by Millikan and collaborators in America. But granting the existence of this agent that discharges highly protected electrometers, it is of importance to seek its origin and particularly to study the probable cosmic effects.

Professor Gerasimovič has taken up at Harvard the theoretical study of cosmic rays, and one of his investigations, which is just published (H. B. 847), concerns the hypothesis of Corlin that the source of the cosmic radiation lies in the long period variable stars, such as Mira. There are hundreds of these stars, mostly faint, undergoing variations of several magnitudes in periods of a few hundred days. They afford, indeed, a plausible source of extremely short wave length radiation, because of their low atmospheric density (being very diffuse, red, gigantic stars) and also because hydrogen is an unduly conspicuous element in their spectra and therefore available for the hypothetical synthesis of chemical elements which might give rise to the extreme radiation-inciting energy changes. Corlin sought to correlate the observed variation in the intensity of penetrating radiation and the variation in the number and total brightness of long period variables above the horizon at corresponding times of the day.

The great number of current observations of long period variable stars, available through the work of the American Association of Variable Star Observers, permits a ready and definite calculation of the total brightness of the variables at any given time. In fact, Mr. Campbell's predictions, published bimonthly and annually from Harvard, permit this calculation for a year or so in the future. Carrying out the analysis, Gerasimovič finds no correlation between the stellar radiation and the cosmic rays. Moreover, he shows that the radiation of cosmic rays would need to be four times as intense as the black body radiation of the same stars to account quantitatively for the daily disturbance of penetrating radiation as recorded in Europe. If the diurnal variations exist, we conclude that they are not closely associated with the behavior of the variable stars.

Globular clusters. The investigations of globular clusters that I have carried out in the past years have been founded mainly on photographs with the large reflectors at Mount Wilson. Great telescopic power was necessary to separate and record adequately the exceedingly faint and concentrated individual stars. An important study of the clusters has, however, just been completed with two miniature Harvard telescopes of two inches aperture—a research that would be quite impossible for the large reflectors. This new work is the determination on a uniform basis of the total light of each of the globular clusters as a whole, and forms one of the steps in determining their relative distances and their uniformity in dimensions and brightness. For this work the individual stars of a cluster are not desired, as the integrated photographic effect can be most satisfactorily measured on plates made with such small telescopes that the images of the clusters are themselves starlike.

To determine the integrated magnitudes of the ninety-five recognized globular clusters, Miss Sawyer has handled hundreds of plates. The study shows some variety among globular clusters, and also indicates that most of the typical systems are much alike in total absolute or intrinsic luminosity. They average 13.4 magnitudes intrinsically brighter than our Sun, and therefore each one radiates about 10^{39} ergs per second.

The brightest of the clusters are, of course, the nearest ones—ω Centauri and ξ Tucanae. They are easy naked eye objects and are about ten magnitudes brighter photographically than the faintest. These two leaders are far south; in fact, eighty per cent. of the globular clusters are in the southern hemisphere, as are most good things (astronomically speaking). This simply means that the solar system is inconveniently located pretty far to the north of the center of the Galaxy.

Iron and stone meteorites. There are on record fifteen times as many falls of meteoric stones as of meteoric irons or stony irons, according to a recent compilation by Miss Mussells, but the total weight of the irons is 2.5 times the total weight of the stones. This ratio of 2.5 may be taken as a measure, or at least as an intimation, of the relative frequency of iron and silicates in inter-planetary and interstellar space; it can be compared with the ratio of iron to stone in the Earth, which Dr. Fisher estimates at 4.5. Only the actual "falls" of meteorites are used in determining the ratio, for, once on the Earth's surface, irons persist but stones rapidly disintegrate, making estimates based on "finds" of meteorites of no significance for this computation.

The total number of recorded falls during the last four centuries, up to the year 1923, is 438. The total number of finds, where the actual fall was not observed, is 411. The total weight of all known falls and finds is some two hundred and fifty tons, a ridiculously small figure compared with the mass of the Earth, which is about 6×10^{21} tons.

New class O stars. There is a particular interest and usefulness in finding and investigating the superlatives—the hottest or smallest or most distant or most something-or-other. It gives us an idea of the extremes of nature and of the scope of our problems. Likewise we seek to add new members to any rare or unusual class of objects in order to provide sounder data for statistical examinations.

The Class O spectrum appears to be a peculiar stage in the life history of very massive stars. Emission and absorption lines are there variously presented, and conditions of high excitation are indicated. The O's have been placed at the top of the temperature scale—perhaps erroneously—and the spectroscopists are not yet in altogether happy accord in matters relating to their classification and to their joining up with the B-A-F, etc., series of more normal and numerously represented spectral classes. We shall have more luck with more data in hand.

To the 140 already known, Miss Payne, in a current publication, adds ten new stars of Class O, two of which are naked eye objects. All are in the southern hemisphere, and of course they lie close along the galactic circle, as do practically all stars of high intrinsic luminosity. These new members of the class have already brought up the question as to the proper limits between the late O stars and the early B's.

Beta Doradus. The discovery of a naked eye variable star with a large amplitude of light variation is certainly unexpected at the present time, for the sky has been studied thoroughly for decades by variable star observers and has been photographed hundreds of times. The far southern star β Doradus, however, not only varies in a ten-day period throughout more than a magnitude, but its variation is of the Cepheid type, for which the light is never constant. A fourth magnitude Cepheid, such as this, is important because of the scarcity of bright Cepheids and also because these variables in general are the most useful stars in the sky. They afford a powerful means of measuring great distances, and since their variations are not restricted to light alone, but affect color, velocity, spectrum and size, they bear on evolutionary problems. The Cepheids are exceedingly large—supergiants, we call them. And this one is a thousand times as bright as the Sun.

The discovery and measurement by Shapley and Miss Walton of the variability of β Doradus on Harvard plates was brought about by reports on spectroscopic researches at the Lick Observatory, most recently by Miss Applegate.

The Lick Observatory, using plates made in Chile, showed that in spectroscopic behavior the star is allied to the Cepheids; the Harvard observers, using plates made in Peru, showed that the star is itself a Cepheid. The photographs that best show the variability are a special series of short exposures on the near-by Nova Pictoris. The brightness of β Doradus had helped to conceal its variation heretofore, for on the usual photographs its images are overdone and so smeared that magnitude estimates are unreliable.

Now that the variability has been found and its period is known, we turn to the old star catalogues and find that the early visual observations had hidden in them the proof of the variability. The conservative astronomers of the past, however, had taken the blame on themselves for the large deviations shown by their measures, instead of mistrusting the star.

Only two or three Cepheids are brighter than β Doradus. The type star of the class, δ Cephei, is one; and the North Pole star is another, but its variation is less than a tenth the amplitude of that of our new southern Cepheid.

Eclipse of the Moon. The lunar eclipse of June 15

was probably the best observed eclipse of the Moon in the history of science. It also brought about the highest degree yet attained in the cooperation of state, church, commerce and science in a single scientific problem. The Canadian and the United States Weather Services, the United States Army Signal Corps, the Roman Catholic Eskimo Mission, the fur traders and trappers along the Arctic Circle, the Royal Canadian Mounted Police, the powerful radio broadcasting stations of the Westinghouse Company, the astronomers of the observatories in western and southwestern America, the newspapers and Science Service, and the amateur astronomical observers over a large part of the United States were all involved in various phases of the meteorological and astronomical observations of this eclipse.

It will be many months before all reports come out of Alaska and from the Canadian Arctic giving information concerning the character of the atmosphere where the grazing solar rays passed and were refracted into the Earth's shadow cone to illuminate faintly, and discolor, the eclipsed Moon.

The general plans for the eclipse observations were developed by Dr. W. J. Fisher, of the Harvard staff, who has specialized in phenomena associated with lunar eclipses; the Canadian work was organized through the efficient cooperation of Dr. R. M. Stewart, director of the Dominion Observatory at Ottawa.

Nova in Magellanic Cloud. A nova in one of the Clouds of Magellan is of more than passing interest. In the first place, such an object has not heretofore been found in either of the Magellanic Clouds, notwithstanding the presence there of practically all other known types of high luminosity stars. In the second place, the distance of the Clouds are known, and therefore the actual luminosities of novae in such places can be computed, which is far from being the case for the nearer novae in our own Milky Way.

While comparing two photographs of the Large Cloud, in a study of stellar motions, Dr. Luyten recently noticed on a plate taken last September a star that was wholly absent from all of the many earlier plates. A search showed its images on eight other plates taken between September 28 and November 6. Just after this last plate was taken the Arequipa telescopes were dismantled for transfer to the new station in South Africa, and the further behavior of the star is unknown.

A cablegram to the South African observatories has resulted in some special photographs being made at the Union Observatory, Johannesburg, but the nova has apparently already disappeared. At maximum brightness the star was difficult enough, being photographically of the twelfth magnitude. But actually, if it is a member of the Magellanic Cloud, it was, when brightest, some ten thousand times as bright as the Sun; the distance accounts for the apparent faintness. And while we are speaking of actualities we should add that it was only the terrestrial recording of a nova that occurred last September—the actual disaster happened nearly a thousand centuries ago.

HARLOW SHAPLEY

SPECIAL ARTICLES

FURTHER STUDIES ON THE ANTIRACHITIC ACTIVATION OF SUBSTANCES BY CATHODE RAYS[1]

IN a previous preliminary report[2] it was shown that, with the exposures used, high-voltage cathode rays[3] applied directly were not effective in healing rickets in rats. On the other hand, it was shown that cholesterol could be endowed with antirachitic potency by exposure to the cathode rays. In our earlier attempt cholesterol was exposed to the cathode rays in a rather thick film and had to be added to the diet in amounts of 0.2 per cent. or more to bring about within two weeks complete healing of rickets in rats, which were rendered antirachitic by the Steenbock rachitic diet No. 2965.[4]

We have since found that, with the film of the substance about a millimeter or less, just as active products are formed by exposure to cathode rays as with ultraviolet irradiation and moreover the time interval is much shorter. In Tables I and II are summarized some of the recent experiments carried out. The cathode ray exposure was in all cases at a distance of 1 inch from the window of the tube and a current of 1 milliampere and 200,000 volts used. The substances were exposed in air and in one instance in an atmosphere of nitrogen. The cholesterol used in these experiments was a commercially pure product. In the experiments with cholesterol purified by the dibromide method, it was first brominated, then debrominated, brominated a second time, again debrominated and finally recrystallized three times from hot alcohol.

From an examination of Table I it is seen that cholesterol exposed to cathode rays for 30 seconds is ef-

[1] From the Laboratory of Biological Chemistry, Albany Medical College, and Research Laboratory, General Electric Company, Schenectady, N. Y. The writer is greatly indebted to Dr. W. D. Coolidge for his valuable advice and assistance, and for the technical assistance of F. S. Randles and H. E. Tanis, Jr.

[2] Knudson, Arthur, and Coolidge, W. D., *Proc. Soc. Exp. Biol. and Med.*, 1927, XXIV, 363.

[3] Coolidge, W. D., *Jour. Franklin Institute*, 1926, ccii, 693.

[4] Steenbock, H., and Black, A., *Jour. Biol. Chem.*, 1925, lxiv, 263.

TABLE I

EFFECT OF CATHODE RAY EXPOSURE ON ANTIRACHITIC ACTIVITY OF CHOLESTEROL

No. of rats	Experimental period, days	Test material	Length of exposure	Amount in diet or daily dose	Results shown by radiographic examination
			seconds		
2	14	Cholesterol, commercial	30	0.05%	Moderate healing
2	14	"	0	0.3 %	No healing
2	14	"	30	0.25%	Moderate
2	14	"	30	0.25%	Beginning
*2	14	"	30 in N	0.25%	Beginning to moderate
2	14	"	30	0.01%	Beginning to moderate
2	14	"	900	0.03%	Moderate
2	14	"	30	1 mg. daily	Beginning
1	14	"	30	2 mg. daily	None
1	14	"	30	2 mg. daily	Advanced
**2	14	"	U. V. 30 min.	2 mg. daily	Advanced
2	14	Cholesterol, purified by dibromide method	30	2 mg. daily	No healing
1	14	"	30	4 mg. daily	"
2	14	"	30	0.05%	"
**2	14	"	U. V. 30 min.	2 mg. daily	"

fective in bringing about healing of rickets in doses of 1 or 2 mg per day. Exposure for as long as 900 seconds does not destroy the antirachitic potency. It is also seen that cholesterol purified by the dibromide method can not be rendered antirachitic by either cathode ray exposure or ultraviolet radiation. This result confirms those of Hess and Windaus,[5] and Rosenheim and Webster,[6] who were unable by ultraviolet radiation to activate cholesterol when thus purified.

* Cathode ray exposure in atmosphere of nitrogen.

** Ultraviolet radiation with Victor Mercury vapor lamp for 30 minutes at a distance of 1 foot.

[5] Hess, A. F., and Windaus, H., *Proc. Soc. Exp. Biol. and Med.*, 1926, XXIV, 171.

[6] Rosenheim, O., and Webster, T. A., *Jour. Soc. Chem. Ind.*, 1926, 45, 932.

TABLE II

EFFECT OF CATHODE RAY EXPOSURE ON THE ANTIRACHITIC ACTIVITY OF INERT SUBSTANCES

No. of rats	Experimental period, days	Test material	Length of exposure	Amount in diet or daily dose	Results shown by radiographic examination
			seconds		
2	14	Dry brewers' yeast, Harris	30	25 mg. daily	Complete healing
2	14	"	0	25 mg. daily	No healing
2	14	Special dry yeast, Fleischmann	30	10 mg. daily	Complete
2	14	Dry brewers' yeast, Harris	30	5 mg. daily	"
2	14	"	30	1 mg. daily	Advanced
1	14	"	30	2 mg. daily	"
2	14	Special dry yeast, Fleischmann previously extracted one week with ether	30	10 mg. daily	"
*2	14	Corn-starch	30	6 per cent.	None
2	14	Cottonseed oil	90	0.1 cc. daily	Moderate
2	14	" "	0	0.1 cc. daily	No healing

In Table II, it is seen that yeast, starch and cottonseed oil can also be activated by exposure to cathode rays. The experiments with yeast are extremely interesting. Yeast which contains ergosterol, considered to be the provitamin of vitamin D,[7] is rendered very potent by exposure to cathode rays. With an exposure of 30 seconds, a dose of 1 mg daily brings about advanced healing of rickets within two weeks. Compared with a good grade of cod liver oil this is at least 10 to 20 times more potent. It is also interesting to note that a yeast which had been extracted previously for one week with ether in a continuous Soxhlet type of apparatus was still rendered very potent, indicating that the substance which is

* The line test showed beginning healing and the cornstarch in this case was exposed in rather thicker film than usual.

[7] Rosenheim, O., and Webster, T. A., *Biochem. Jour.*, 1927, XXI, 389.